International Journal of Information Processing, 6(4), 55-63, 2012
ISSN : 0973-8215
IK International Publishing House Pvt. Ltd., New Delhi, India

Recursive Partitioning for Process Improvement: Control Study of a Petrochemical Process

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Recursive partitioning produces a classification tree in which factors are assigned to mutually exclusive subsets as per set of predictor variables. In this work recursive partitioning has been used as a substitute to multiple linear regression for multi variable analysis of data from a petrochemical process for Poly Butadiene Rubber (PBR) plant for control of its product quality parameter, Mooney viscosity. Poly Butadiene Rubber is used in rubber processing industries. Mooney viscosity is an important quality parameter of PBR. The design range of Mooney viscosity of the product from last reactor outlet is in the range of 37-47. Reduction in the variation in Mooney viscosity improves product quality and results in greater customer satisfaction. Data mining techniques have been used to analyze the Mooney viscosity and process variable data to obtain range of values of process variables that result Mooney in the desired range of 37-43. Recursive partitioning identified various subgroups with different mean values of the quality parameter. Of all the subgroups, the classification tree produced by recursive partitioning that consisted of 5 factors is found to be suitable to get the desired range of Mooney viscosity value.

Keywords : Mooney Viscosity, Polybutadiene Rubber, Recursive Partitioning.

1. INTRODUCTION

Achieving a uniform product quality is more difficult in polymerization processes than in short chain reactions as the product quality properties are very sensitive to process conditions. Any upsets in feed and catalyst conditions, mixing and temperature, can change the critical product properties such as viscosity, molecular weight and degree of branching. Most of the advanced process control methods are limited to temperature and pressure control. The lack of on line sensors for the product quality properties is due to the complex nonlinear dynamics of the polymerization processes.

Control of the product quality requires an accurate model that can predict desired properties as a function of operating variables. The mechanistic modeling of polymerization processes is very complex, time consuming and difficult. The conventional approach based on linear models like multiple linear regression and principle component analysis are not suitable for highly nonlinear polymerization processes [1]. Data mining is the analysis of large data sets with the goal of finding unsuspected relationships. Large data sets include large number of records noted on large number of variables. Data mining techniques can lead to local models and global models. Local models are limited to restricted range of variable values. Models associated with data mining techniques include regression analysis, clustering and neural networks. Neural net works are data based models and given sufficient data the neural networks are capable of modeling nonlinear processes to a desired degree of accuracy [2–4]. The neural network models have been applied in process modeling and control [5–7]. Model is useful for inferential estimation and control of the quality. But if the objective is reduction of variation in quality parameter, then range of process

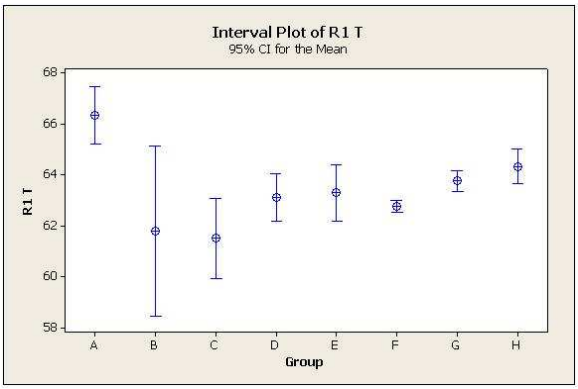

Figure 11. Column Contribution

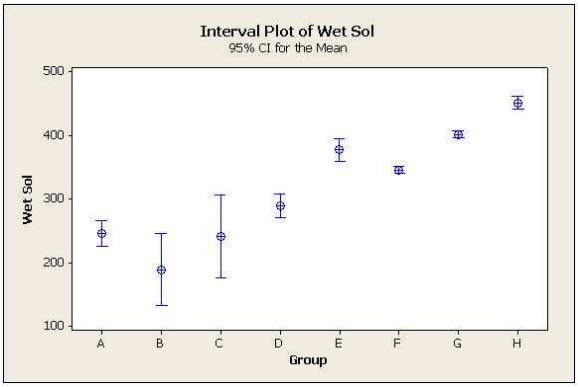

Figure 12. Column Contribution

the desired response variable in the range of interest. Data partitioning and interval plots are used to get the desired result. The critical variables that will have major impact on Mooney obtained from the data analysis are as expected and in line with the actual process. Minitab and JMP software were used to analyze the data. The results give direction to reduce the variation in Mooney viscosity which results in greater customer satisfaction. The approach presented in the paper can be used for analysis of other processes also. These analysis gives direction to process engineers during operation and control.

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